Pro3GPP TSG-RAN WG3 Meeting #114-e Draft R3-215911

E-meeting, 1– 10 Nov, 2021

**Agenda item: 18.4.3**

**Source: CATT (moderator)**

**Title:**  **CB: # AIRAN3\_Mobility -** **Summary of email discussion**

**Document for: Approval**

# 1 Introduction

**CB: # AIRAN3\_Mobility**

**- Converge on the left issues on the input/output, feedback, solution**

**- Merging any agreement parts; provide TP if agreeable**

**- Capture agreements and open issues**

(CATT - moderator)

Summary of offline disc in [R](file:///D:\Meetings\RAN3%23113\CB\Inbox\R3-214222.zip)3-215911

Two phases of this email discussion:

* Phase 1 Deadline: **18:00PM UTC, 5th Nov**.
* Phase 2 Deadline : **8:00AM UTC, 9thNov**, Try to have an agreeable TP in the 2nd phase discussion before online session.

# 2 For the Chairman’s Notes

# 3 Discussion

## 3.1 Use case

In [5130], it is proposed to include AI-based beam training and tracking strategies of millimeter wave communication especially in the high-speed rail scenario into the use case description part for AI based mobility management

**Q4.1-1 Companies are invited to provide views on whether the new use case on AI-based beam training and tracking strategies of millimetre wave communication should be introduced in** AI based mobility management **in RAN3.**

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| **Company** | **Yes/No** | **Comment** |
| InterDigital | No | These topics are better handled in air interface AI studies (upcoming in R18) |
| Huawei | No | We think it should be the common understanding that the current SI should focus on the agreed use cases. |
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In [5666],it is proposed to introduce the following events for **Reduction of the probability of unintended events associated with mobility case:**Successful HO with underlying issue, too early or to late PSCell change, triggering PSCell change to wrong PSCell.

**Q4.1-2 Companies are invited to provide views on whether the above events should be included or not.**

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| **Company** | **Yes/No** | **Comment** |
| InterDigital | Yes | We are ok with adding these |
| Huawei | Yes | We think these are the main cases that can be significantly promoted by AI. |
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## 3.2 Solutions and standard impacts

### 3.2.1 General

In [4816], it is proposed to add a new chapter *Locations for* *AI/ML Model Training and AI/ML Model Inference* and move the listed options for the location of AI/ML Model Training and AI/ML Model Inference into this chapter.

**Q3.2.1-1 Companies are invited to provide their views on the restructure i.e. a dedicated chapter for all possible options on the location of AI/ML Model Training and AI/ML Model Inference.**

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| **Company** | **Support/not support** | **Comment** |
| InterDigital | Support | We need to do this or something like this. Having text in the section 5.3.2 is frowned upon in drafting specifications if there are subsections 5.3.2.1, 5.3.2.2. This is just editorial. A different heading for the new 5.3.2.1 is ok, this is just our suggestion. |
| Huawei | No strong opinion | The more important is to make things clear, as to the structure, either way could work. What is missing is that we think for offline training, technically it should not be located inside RAN. |
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In [5479], it is proposed to introduce the following bullets in general part.

1. For the AI/ML Mobility Use Case, a gNB can train and execute an ML model to determine which UE configuration it can provide to its UEs.

The main intention of introducing this bullet is copied as below:

*In case the source gNB has multiple possible target gNBs for handover, all satisfying radio conditions, the source may estimate the UE configuration at each candidate target gNB and make a more informed decision on the target node. This could also help to improve CHO preparations to the best possible candidate target cells. This can save unnecessary resource reservations to target gNBs that are not selected finally by the source gNB as well as unnecessary signaling to release the resources through handover cancellation messages.*

1. Capture the different options on locations of *AI/ML Model Training and AI/ML Model Inference for* trajectory prediction.

The different options are as blew:

*Considering the locations of AI/ML Model Training and AI/ML Model Inference for mobility solution, following two options are considered:*

* *The AI/ML Model Training function is deployed in OAM, while the Model Inference function resides within the RAN node*
* *Both the AI/ML Model Training function and the AI/ML Model Inference function reside within the RAN node*

*Furthermore, for CU-DU split scenario, following option is possible:*

* *AI/ML Model Training is located in CU-CP or OAM, and AI/ML Model Inference function is located in CU-CP*

1. The study should consider solutions to obtain data for trajectory prediction of a given UE beyond the next cell change with the following reasons.

*Considering UE could not always support location report and only limited trajectory prediction can be supported in legacy networks by using UE history information from neighbour NG-RAN nodes, it is proposed to enable a NG-RAN node to obtain not only information about the next cell change (handover or cell-reselection), but also UE mobility information over a number of cell changes a UE makes into the future. With this, it can give network an enhanced view of UE trajectory which can be used to improve HO related actions.*

4) Capture the requirements for trajectory prediction as below:

* Restrict the amount of mobility history information only to gNBs that have requested such information
* Allow to obtain information on UEs that camped also in idle mode on cells under the gNB.

The rationale to introduce this bullet is copies as follows:

*One simple way of obtaining trajectory information over a number of cell changes, to be used for the training phase of an ML algorithm at the gNB (gNB-CU), is to mandate each of the gNBs that have served a UE to inform all previous serving gNBs where the UE was connected/camped on about UE mobility information, e.g., visited cell/radio measurements. However, it is likely that only a minority of gNBs will require such training information. Therefore, systematically sending this information would introduce a lot of extensive signaling and would not be preferable. A first requirement for a trajectory prediction solution should therefore be that UE mobility information for training purpose is only sent to gNBs that request such information. A second requirement is to obtain information on UEs that camped in idle mode on cells under the gNB.*

**Q3.2.1-2 Companies are invited to provide their views on the above 4 bullets.**

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| **Company** | **Views** | **Further Comment** |
| Huawei | 1. Not sure the benefits 2. Clarifications needed 3. Clarifications needed   In principle yes but | 1. We think the AI/ML inference output should be able to make a reasonable decision for each UE, since the decision could be per UE basis, and input for each UE is different, not sure what additional considerations needed. 2. We already agreed that training could be located in different place, it seems that this proposal is for trajectory prediction only? And any specific points/issues to be addressed here? 3. In general we agree that trajectory prediction should be useful, which could be used as input for HO decision, but what this proposal means, the trajectory info should include “*a number of cell changes a UE makes into the future*”?   Just try to understand the exact meaning, the first bullet seems to say that gNB should initiate the request for mobility history? And the second bullet requires the mobility history information should support idle? |
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In [5474],there are two proposals regard to the general part：

1. Remove the listed options on the location of Model training and Model Inference for CU/DU split scenario and only clarify that Model Inference can be in the gNB-CU.
2. To improve the mobility decisions at a gNB (gNB-CU), a gNB can request mobility feedback from a neighbouring node. Details of the procedure are FFS.

**Q3.2-3 Companies are invited to provide their views on the above proposals.**

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| **Company** | **Views** | **Further Comment** |
| Huawei | Fine |  |
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In [5666],it is proposed to capture that offline training is in OAM and online training is in NG-RAN node.Futhurmore,it is proposed to add a note that it is not precluded that offline training could be deployed in the gNB by implementation. **Q3.2.1-4 Companies are invited to provide their views on the above proposals.**

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| **Company** | **Views** | **Further Comment** |
| Huawei | Agree | As the proponent, of course we think we need to make things clearer. |
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### 3.2.2 AI/ML Model Training in OAM and AI/ML Model Inference in a NG-RAN node

In [5526], it is proposed to introduce a flowchart which clearly describes the interaction between UE and NG-RAN node as well as the interaction between NG-RAN node and OAM. The intention is to make the solution much integrity and stable.

In [5666], there is also proposal to have a flowchart which also include mobility enhancement cases.

**Q3.2.2-1 Companies are invited to provide their views on whether the new introduced flowchart is needed or not. If it is needed, whether the description on each step is agreeable?**

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| **Company** | **Yes/no** | **Further Comment** |
| Huawei | Yes | We think to introduce a flow chart would be better to describe the mechanisms. |
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In [5270], it is proposed to add description that *NG-RAN node can also continue model online training based on the received AI/ML model from OAM.*The main reason is as follows*:*

*Mobility optimization has higher requirement to real-time performance. The real environment of each NG-RAN node is very essential to making the most accurate decision for mobility optimization. Hence, supporting continuous/further training at NG-RAN node on top of received AI/ML model from OAM is very important for mobility optimization use case.*

**Q3.2.2-2 Companies are invited to provide their views on whether** *NG-RAN node can also continue model online training based on the received AI/ML model from OAM***.**

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| **Company** | **Yes/no** | **Further Comment** |
| Huawei | Yes | We think that, for online training, this should be a typical way that NG-RAN could perform online training over a trained model received from OAM. |
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In [5666],it is proposed to introduce descrption on the impact to Xn interface as below

**Potential standard impacts:**

* **Xn interface impact:**
  + Delivery of the UE trajectory/mobility/performance prediction from the source NG-RAN node to the target NG-RAN node;
  + Predicted load info from candidate target NG-RAN node to source NG-RAN node
  + Performance Feedback of the received UE trajectory/mobility/performance prediction from the target NG-RAN node to the source NG-RAN node.

**Q3.2.2-3 Companies are invited to provide their views on above proposal.**

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| **Company** | **Yes/no** | **Further Comment** |
| InterDigital | No | We don’t disagree with the points made but this information is or should be included in the input and output data sections |
| Huawei | Yes | The messages mentioned above are necessary for mobility enhancements. |

### 3.2.3 AI/ML Model Training and AI/ML Model Inference in NG-RAN node

Currently, in the flowchart, there are 8 steps while only 7 steps in the procedure description, there are several alternatives to fix this part

1. In the procedure text, add description on step 8 and keep the flowchart unchanged[5526][5563][5332]
2. In the flow chart, change the step 8 as handover initiation procedure and also add description on step 8[4816]
3. In the flow chart, add step 9 which is the feedback from NG-RAN node 2 to NG-RAN node 1 and add the description on it[5270][5474]

**Q3.2.3-1 Companies are invited to provide their views on which alternative are preferred**

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| **Company** | **Which alternative are preferred** | **Further Comment** |
| InterDigital | 2 | Step 8 should be described so 1) is an alternative. We made step 8 a box since HO and related include messages to the UE.  We are not against adding a step 9 as in 3) |
| Huawei | Slightly prefer 1) |  |
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There are some other proposals on this topic as below:

1) In [5526] and [5563], it is proposed to include UE predicted trajectory in handover request message for NG-RAN node 1 to NG-RAN node 2 for future mobility optimization. The proposal also applied to 3.2.2.

2) In [5332], it is proposed to introduce two steps via which NG-RAN node 1 could obtain input from NG-RAN node 2 for model training and model inference separately.

3) In [4816],it is proposed to introduce Xn procedure to allow NG-RAN node 1 receives asynchronously reports from neighbour NG-RAN node2 for model training.

4) In [4816], it is proposed to clarify that report from UE and other adjacent NG-RAN node could be repeated for several times.

5) In [4816], it is proposed to clarify that the UE measurement report serve as reference data for real-time or near real time mobility optimization.

6) In [5474],it is proposed to introduce a class 1 procedure to allows NG RAN node 1 to subscribe to the Mobility

Feedback Update of the neighbouring NG RAN nodes.

**Q3.2.3-2 Companies are invited to provide their views on above bullet****s**

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| **Company** | **Yes/no** | **Further Comment** |
| InterDigital | Yes for 3,4,5  Maybe on 1, 2, 6 | First to clarify 3 – we introduce a message from NG-RAN node 2 because there are inputs from neighbouring NG-RAN nodes. The Xn procedure is not a new one (but could be SHR, RLF report, or other messages.  Not necessarily against 1 or 6 but we feel it is not necessary to discuss exactly which messages are to be added or modified. The work item can decide that.  For 2 we mostly agree, but it is not clear we need two separate messages from NG-RAN node 2. |
| Huawei | See comments | Technically most of the proposals are not wrong, but not sure if we should step into such detailed discussion, e.g. a new procedure, how UE predicted trajectory info is exchanged (even, if there is a need to exchange), whether class 1 or class 2 should be used or not; especially for 5) and we don’t understand what real-time or near real time means, we think measurement report from UE could be used for model training and inference as well, what else? |
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### 3.2.4 Input data

There are still 5 FFSs on the input data which is required for mobility management and different views are provided in [4816][5270][5332][5479][5526][5528][5563][5699].The input data which is still FFS is as below:

**Input Information from UE:**

* a)FFS UE historical location information from MDT, e.g., Latitude, longitude, altitude, cell ID
* b)FFS predicted traffic

**Input Information from the neighbouring RAN nodes:**

* c) Position, resource status, FFS QoS parameters of historical HO-ed UE (e.g., loss rate, delay, etc.)
* d)FFS Information about the performance of handed over Ues

*e)FFS on whether new UE measurements are needed.*

**Q3.2.4-1 Companies are invited to provide their views on whether the above information could be used as input data for mobility management?**

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| **Company** | **Yes/no** | **Further Comment** |
| InterDigital | Yes | For UE historical location from MDT, we moved it to the 3rd bullet since it also includes UE historical information, we kept the FFS in our contribution but are ok with removing the FFS. We also clarified in this UE history bullet clarify it is collected over time, not by a single UE message, to avoid confusion with UE history passed as a group over Xn. |
| Huawei | In general yes, but | Anyway we think there should be further discussions on each detailed parameter case by case, e.g. it should be useful for some KPI info such as loss rate, delay, throughput, but we may have to confirm one by one during normative phase.  And maybe we need to clarify here the difference between QoS parameters of historical HO-ed UEs and performance of HO-ed UEs;  For new UE measurement, we think FFS should be kept. |
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**Some other information proposed to be included as input data is listed below：**

Information from CN (the input can be based on the information from AI based CN function):

* 1)UE mobility statistics parameters, e.g., UE location statistics (duration of the time slot) [5528]
* 2)UE mobility predications, e.g., predicated UE location information in the analytical period[5528]

Information from the neighbor RAN nodes:

* 3)Load prediction[5332]
* 4)UE’s successful DC offloading information in the past and received from neighboring RAN nodes[5528]
* 5)Information about the performance of handed over UEs and offloaded DC Ues[5528]
* 6)Estimated Network Performance (if the neighbour RAN node is a Target gNB)[5479]
* 7)Cost of CHO Handover preparation e.g., reflecting the impact in terms of preparation time [5479]
* 8)UE performance prediction/estimation[5474]
* 9)UE dwelling time per cell[5474]
* 10)RAN visible QoE metrics e.g., buffer level[5474]

Information from UE:

* 11)Near-term UE location information in the future, e.g. future location received from UE’s application layer, future location predicted by AI/ML model at the UE side[5270]
* 12)RAN visible QoE metrics e.g., buffer level[5474]
* 13)Trajectory information[5474]
* 14)UE Mobility history information[5474]
* 15)UE trajectory[5474]
* 16)SON Reports of handovers that are successful handover report,[5474]

Input Information from Local node:

* 17)UE’s CQI, SRS(local node) [5270]
* 18) Remove the bullet UE trajectory prediction output (will be used by the RAN node internally)[5474]

Input Information from LMF:

* 18)Historical UE location information[5270]
* 19)Predicted UE location information[5270]

**Q3.2.4-2 Companies are invited to provide their views on whether the above information could be used as input data for mobility management?**

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| **Company** | **Yes/no** | **Further Comment** |
| Huawei | See comments | (1), (2): not needed for now. For RAN related use case, we are not sure what useful info RAN could get from CN;  For 3), this was also discussed in LB use case, technically the load prediction info might be also useful for mobility decision；  For 4) and 10), not sure if there are any obvious benefits to mobility optimization.  OK for 5) 6) 7) 9), we could further discuss the need of them, maybe we could just list one of them as example.  For 4), 8) and 10), not sure the benefits to mobility optimization, e.g. RAN visible QoE metrics, they are mainly for resource usage evaluation, what’s the need to predict a UE’s performance, etc.  OK for 14) and 16), they are normal SON or MDT related info concerning mobility; for other information listed in (11~16), it seems that RAN could generate them, there are overlaps here, e.g. UE trajectory prediction could be done by RAN.  For 17) and 18), we are not sure, does mobility require precise positioning info from LMF, maybe not needed.  In general, some of those info might be useful, but not sure we should go one by one, we could start from what might not be needed for the moment, e.g.: we think further discussions are needed on whether there is a need to get information from CN; why RAN visible QoE metric is useful to mobility enhancements; for trajectory prediction, if RAN could do that, why we need from UE? Similar comments to UE performance prediction/estimation. |
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### 3.2.5 Output data

One FFS i.e. *FFS* *UE trajectory prediction (Latitude, longitude, altitude of UE over a future period of time)* is left on the output data. Among the contributions which discuss this issue, only one company thinks *UE trajectory prediction* should not be the output data[5270][5474] while the others[5056][5332][5526][5563][5699] [5528]support to keep it as output data.

The main reason not to include *UE trajectory prediction as output data* is as follows:

* Location information reported in measurement report depends on the positioning procedure. The detailed location information (e.g. longitude, latitude, altitude, etc) is transparent to NG-RAN node.
* It is considered UE trajectory prediction is performed and collocated with nodes which can perform legacy positioning calculation and already have UE’s location information, i.e. UE and LMF, which can reduce frequency of exchanging UE history location information and reduce complexity.
* It is not needed to predict the trajectory information at the local node as this can be derived from UE speed and UE position

**The reason to keep** *UE trajectory prediction as output data* is as follows:

* + - Outputting RRC decisions directly based on raw inputs collected throughout the network may not fully utilise the benefit of AI/ML and UE trajectory prediction can be used as input for the mobility decision.
    - Deploying the AI/ML function of UE location prediction at the UE or the LMF has drawbacks comparing to the UE location prediction in NG-RAN node.For example, it is too energy and timing consumption to do it in UE side and LMF is far from Uu interface.
    - It is not necessary to make the geographical location information an input of model inference of geographical location prediction—in a sense the UE geographical location prediction module can be integrated with the UE positioning module.
    - UE trajectory prediction could be transferred to the target NG-RAN node for reference via Handover request. Hence, UE trajectory prediction should also be included as the output data.

**Q3.2.5-1 Companies are invited to provide their views on whether** *UE trajectory prediction* **could be regarded as output data?**

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| **Company** | **Yes/no** | **Further Comment** |
| Huawei | See comments | Maybe the first thing is, trajectory prediction is anyway needed, and it even could be outcome of inference, then technically there are two approaches here, one is that this is just used as an input for traditional HO decision making; the other is that this is used as input for another model training for HO decision. |
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**Some other proposals to introduce more output data or to update on the existing output data are listed below：**

* 1)Target PSCell in PSCell addition and change[5332](new)
* 2)Candidate PSCells in CPAC[5332](new)
* 3)UE trajectory prediction (Latitude, longitude, altitude of UE over a future period of time)

Estimated arrival probability in CHO and relevant accuracy and confidence interval[5332]

* 4)Predicted handover target node, candidate cells in CHO, may together with the accuracy and confidence of the predi[5332]
* 5)the predicated target SN node IDs for DC together with the confidence of the predication[5528](new)
* 6)Validity time corresponding to predicted handover cells and predicted candidate cells[5270]
* 7)Estimated arrival probability, priority and handover execution timing of predicted candidate target cellsand relevant confidence interval[5270]
* 8)Estimated arrival probability (particularly for CHO, but is relevant for all HO types) and relevant confidence interval for HO and data forwarding optimization strategies[4816]
* 9)Predicted handover target node in the case of legacy and DAPS HO, list of candidate cells in CHO, together with the confidence of the prediction[4816]
* 10)Traffic predictions for resource allocation purposes in mobility (for CA/DC activation/deactivation and Data Forwarding decisions.) [4816](new)

**Q3.2.5-2 Companies are invited to provide their views on whether the above information could be output data?**

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| **Company** | **Yes/no** | **Further Comment** |
| InterDigital | Yes on 1,2,5  Yes on 8  Yes on 9  Yes on 10  Open to 3, 6 | Bullets 1, 2, and 5 should be combined to handle DC issues  Bullet 3 (part) 7 or 8 modify the same text. Estimated arrival probability is relevant for CHO but it applies in general to HO, so we like wording in 8 better but would support adding accuracy to the text as per in the second line of 3.  This overlaps with 4, Predicted handover target node applies to all handover times (list of candidates for CHO) |
| Huawei | See comments | Some of them are overlapped  OK for 1) 3) 5) 7) 8) 9) 10); 4) should be output of inference, but as commented, we are not sure the benefits of accuracy and confidence, 9) is subset of 4)?  Again, we are not sure if we should go through one by one, maybe we could start from some of them, e.g. 1), 9)? |
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### 3.2.6 Others

In [5332], it is proposed to introduce a chapter for rewarding information as below:

5.3.2.x Rewarding Information

* The feedback from the target SpCell or the UE whether the mobility decision is good or not (e.g. if mobility is successful)

In [5270],it is proposed to introduce a chapter for feedback as below

5.3.2.5 Feedback

* Throughput, packet delay of the handed-over UE, etc

**Q3.2.6-1 Companies are invited to provide their views on above proposals**

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| **Company** | **Yes/no** | **Further Comment** |
| Huawei | Not needed | Rewarding information is part of model training itself, we already agreed to have feedback, not sure what else we need, then maybe there is no need to introduce a new chapter. |
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# References

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| --- | --- | --- |
| [R3-214816](file:///D:\\会议硬盘\\TSGR3_114-e\\Docs\\R3-214816.zip) | Correction of Mobility Optimization - Solutions and standards impacts (InterDigital ) | Other |
| [R3-215056](file:///D:\\会议硬盘\\TSGR3_114-e\\Docs\\R3-215056.zip) | Discussion on Standards Impact on Mobility (CATT) | Discussion |
| [R3-215130](file:///D:\\会议硬盘\\TSGR3_114-e\\Docs\\R3-215130.zip) | Further discussion on use case of mobility optimization (Purple Mountain Laboratories) | Discussion |
| [R3-215270](file:///D:\\会议硬盘\\TSGR3_114-e\\Docs\\R3-215270.zip) | AI/ML based mobility optimization (Intel Corporation) | Discussion |
| [R3-215332](file:///D:\\会议硬盘\\TSGR3_114-e\\Docs\\R3-215332.zip) | Discussion on standard impact to support mobility optimization (Lenovo, Motorola Mobility) | Discussion |
| [R3-215479](file:///D:\\会议硬盘\\TSGR3_114-e\\Docs\\R3-215479.zip) | (TP for TR 37.817) Further Discussion on Standard Impacts of AI/ML Mobility Optimization (Nokia, Nokia Shanghai Bell) | Other |
| [R3-215526](file:///D:\\会议硬盘\\TSGR3_114-e\\Docs\\R3-215526.zip) | Further discussion on solution to AI-based mobility optimization (ZTE Corporation, China Unicom) | Other |
| [R3-215528](file:///D:\\会议硬盘\\TSGR3_114-e\\Docs\\R3-215528.zip) | Input/output information for support of AI/ML enabled Mobility Optimization (LG Electronics) | Discussion |
| [R3-215563](file:///D:\\会议硬盘\\TSGR3_114-e\\Docs\\R3-215563.zip) | Discussion on Standard Impact for AI/ML based Mobility Optimization (Samsung, Verizon Wireless) | Discussion |
| [R3-215699](file:///D:\\会议硬盘\\TSGR3_114-e\\Docs\\R3-215699.zip) | Remaining issues for AI based Mobility and Energy Saving (CMCC) | Discussion |
| [R3-215666](file:///D:\\会议硬盘\\TSGR3_114-e\\Docs\\R3-215666.zip) | (TP to TR 37.817) Remaining issues for AI based mobility enhancements and load balancing (Huawei) | other |
| [R3-215474](file:///D:\\会议硬盘\\TSGR3_114-e\\Docs\\R3-215474.zip) | AI/ML Load Balancing and Mobility Optimization use cases (Ericsson) | Other  Move to 18.4.2 |

# 5 Conclusion, Recommendations [if needed]

If needed